MICROBIOLOGICAL WATER FILTER

This application is a continuation of U.S. application Ser. No. 09/382,278, filed with the U.S. Patent Office on Aug. 25, 1999, now U.S. Pat. No. 6,187,192.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates generally to the field of solution and fluid filters or purification devices, primarily to aqueous solution filters and water purification, devices for gases and water and other aqueous liquids, which remove contaminants from the gas or aqueous liquid solution passed through them. In its more particular aspects, the invention relates to the field of such devices that remove microbiological contaminants, including bacteria and viruses, from water or aqueous solutions.

2. Description of Related Art

Purification or filtration of water or other aqueous solutions is necessary for many applications, from the provision of safe or potable drinking water to biotechnology applications including fermentation processing and separation of components from biological fluids. Similarly, the removal of microbial organisms from breathable air in hospitals and clean rooms, where ultrapurified air is required, and in environments where the air will be recirculated, such as aircraft or spacecraft, is also an important application for filtration media. In recent years, the need for air filtration and purification in the home has become more recognized, and the competing concerns of energy efficiency and indoor air quality have lead to numerous air filtration products, such as HEPA filters and the like, that purport to remove small particles, allergens, and even microorganisms from the air.

There are many well known methods currently used for water purification, such as distillation, ion-exchange, chemical adsorption, filtering or retention, which is the physical occlusion of particulates. Particle filtration may be completed through the use of membranes or layers of granular materials, however in each case the pore size of the material and the space between the granular materials controls the particle size retained. Additional purification media include materials that undergo chemical reactions which alter the state or identity of chemical species in the fluid to be purified.

In most cases a combination of techniques are required in order to completely purify fluids, such as water. Combinations of technologies may be implemented by combining functions in a single device or using several devices in series where each performs a distinct function. Examples of this practice include the use of mixed resins that remove both negative and positively charged chemical species as well as species without charge

Many of these water purification techniques and practices are costly, energy inefficient and/or require significant technical know-how and sophistication. Traditional means of reducing these complications require extensive processing or specially designed apparatus. Unfortunately, development of low cost techniques do not adequately address the removal of harmful biological contaminates, bacteria and viruses. For example, simple point-of-use purification devices, such as filters attached to in-house water supply conduits or portable units for campers and hikers, cannot sufficiently remove bacteria and viruses unless relatively costly membrane technology or strong chemical oxidizers, such as halogens or reactive oxygen species, are utilized.

The Environmental Protection Agency (EPA) has set forth minimum standards for acceptance of a device proposed for

use as a microbiological water purifier. Common coliforms, represented by the bacteria *E. coli* and *Klebsiella terrigena,* must show a minimum 6-log reduction, 99.9999% of organisms removed, from an influent concentration of 1×10^7/100 ml. Common viruses, represented by poliovirus 1 (LSc) and rotavirus (Wa or SA-11), which show resistance to many treatment processes, must show a minimum 4 log reduction, 99.99% of organisms removed, from an influent concentration of 1×10^7/L. Cysts, such as those represented by *Giardia muris* or *Giardia lamblia,* are widespread, disease-inducing, and resistant to chemical disinfection. Devices that claim cyst removal must show a minimum 3 log reduction, 99.9% of cysts removed, from an influent concentration of 1×10^6/L or 1×10^7/L, respectively. The EPA has accepted the use of other particles in the appropriate size range as a means of testing devices that claim this function.

Materials that are highly efficient at removing and immobilizing microbial organisms have numerous applications, but a particular area of application is in the biotechnology and fermentation industries. Not only would such materials be useful in the processing of fermentation broth for recycling or reuse, they also would have utility as microbial immobilization materials for the microbes of interest to the fermentation process.

It is known to use apatite, tricalcium phosphate and some derivatives thereof in granular, particulate or fiber form as a microbe binding agent. Apatite in the form of hydroxylapatite (HA) can be produced through wet-process chemical synthesis, the processing of animal bones, or the processing of phosphate-based minerals. Hydroxylapatite can function as a biological water purification agent through a complex process, which includes the chemical adsorption of biological materials and organisms.

An example of the use of HA, generated through a wet chemical synthetic method is shown by Okamoto in U.S. Pat. No. 5,755,969, which discloses the use of pure HA thin fibers or whiskers isolated in a particular crystal structure (a particular mean c-axis length and aspect ratio). The synthetic strategy and material processing methods were claimed to be unique. Okamoto further suggests at column 1, lines 60–67 that HA that has been obtained by extraction from natural organisms or synthesized by wet processes is generally poor in crystallinity and has poor adsorbability, and that if these materials are used as a microbe-removing material, the liquid permeability of the material cannot be assured.

There are no known commercially available filtration or purification devices incorporating HA compounds. Prior patent art and reported literature indicating the use of HA as a filtration material have never demonstrated capabilities which indicate that a device created with such materials could meet the minimum EPA requirements described above. For example, test data presented by Okamoto in U.S. Pat. No. 5,755,969 indicates that his device and other HA containing devices reduce viruses by only 99.76% at best.

Accordingly, there remains a need in this art for an uncomplicated, inexpensive fluid purification and filtration method and device incorporating apatite and/or hydroxylapatite. There is also a need for a practical fluid purification and filtration device and method that permits the use of apatite and/or hydroxylapatite in readily available and commonly found forms, such as those obtained by extraction from organisms or synthesized by a variety of different methods. There is also a need in the art for a method and device that not only meets, but significantly exceeds, the minimum EPA requirements for designation as a microbiological water purifier, such that the device is more than suitable for consumer and industry point-of-use applications.